Zaire
A proposed small hydropower and rural electrification project

NRECA Small Decentralized Hydropower (SDH) Program
Zaire: A proposed small hydropower and rural electrification project

By Joe Howe and Songthara Omkar

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International Programs Division

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Providing training services in such topics as operation and maintenance, resource assessment, management, and fabrication
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Executive summary

Both the potential and the need for the development of small hydroelectric power stations in Zaire are great. This encapsulates the findings of a National Rural Electric Cooperative Association (NRECA) team sent to examine the situation. (A full description of the trip's goals and agenda is found in appendix A of this report.) The NRECA recommends that hydroelectric power be developed through the use of a Small Hydropower and Rural Electrification Project (SHREP) that is jointly financed by USAID and other donor organizations. USAID's role in this development could vary according to options outlined in this report.

The project would provide technical assistance, training, and partial financing for approved small, hydroelectric projects. USAID and other assistance would be of immediate and long-term impact, since there are both immediate and long-term needs. The cost of the full project as outlined herein--an order of magnitude estimate--is $55 million during a project life of 5 years, 50% of this would be in local currency.

The NRECA team believes that support of donors other than the USAID is quite important for the success of this project. To obtain this support, NRECA suggests the formation of a donor coordinating committee and the circulation for review of the USAID planning documents (PID and PP) among potential donors.

While meeting Zaire's immediate energy needs is of greatest concern, it is also important to assist the government of Zaire (hereafter, government) in obtaining a comprehensive energy resource inventory, knowledge of alternative energy sources and forecasts of power demands. The full SHREP would provide the technical assistance necessary to establish a sound basis for completion of these longer term studies. Without them no rational energy policy or optimum system of rural electrification can be developed.

Since numerous logistical and administrative problems will arise, the SHREP team should include at least one expert in this area. This will preclude what has happened on USAID projects in other countries where technicians have often been diverted from their primary responsibilities, and poorly executed projects have resulted.
Contents

Executive summary, iii

Introduction, 1
Purpose of report, 1
The context of hydropower development in Zaire, 1

Type of assistance required in small hydropower development, 4
The need to increase the capabilities and performance of institutions, 4
The need for planning, 4
The need for training, 5
The need for program development, 5
The need for financing, 5

Option A: Full multidonor program, 6
A coordinated and comprehensive intervention, 6
Demonstration and pilot sites, 6
Skills required, 6
Technical assistance, 7
Procurement, 8
Donor coordination for SHREP, 9
Suggested duration (project life) SHREP, 9
Budget for SHREP, 9
Roles and contributions to the project, 10
Training, 11
Implementation schedule, 13

Alternative options for consideration by USAID, 14
Option B, 14
Option C, 14
Option D, 14
Option E, 14

Appendix
A. Scope of work, 16
B. Project guidelines, 18
1. Criteria for site selection, 18
2. Criteria for rank-ordering potential projects by priority, 20
3. Standardization and simplification of equipment, 23
4. Guidelines for cost estimating, 25
5. Guidelines for determining economic feasibility, 26
6. Appropriate standards for project, 28
C. Preliminary assessment of sites, 29
D. Contacts made in Kinshasa, 43
E. References, 44
F. Team composition, 46

v Contents
Introduction

Purpose of report

The purpose of this NRECA report is to assist USAID in planning a strategy for assistance to rural mini-hydropower development in Zaire. As requested, the report also discusses: the criteria for site selection; proposed institutional roles in this development; potential multidonor involvement; possibilities for standardization of equipment; guidelines for economic analysis; and training requirements for small hydropower development. Preliminary appraisals of several existing and proposed small hydro systems are presented in appendix C.

The context of hydropower development in Zaire

Situated in central Africa, Zaire has an area of more than 2.3 million square kilometers (roughly the same as the United States east of the Mississippi River), and a population of about 25 million (1976 data). Although its mining and agricultural potential is large, it is economically very underdeveloped, having few indigenous industries and very poor roads. Many areas of the country either have no electricity or are served by expensive diesel-generated power. This energy shortage is an increasing economic and social constraint in Zaire.

The potential for hydropower development in Zaire is very large. It has been estimated that Zaire has about 13 percent of the total world hydroelectric potential.\(^1\) The number of feasible sites for small hydropower development probably exceeds 1,000. However, only recently has the government given a high priority to small hydro.

The principal government organizations involved in energy development are--

Department of Energy--This department has review/approval authority over all energy projects and has responsibility for general energy planning and policy. It relies on the Société Nationale Electrique for implementation.

Société Nationale Electrique (SNEL)--This is an implementing agency under the Department of Energy. It has been primarily involved with electrical systems supplying urban centers and with the two Inga Shaba dams and transmission line. This line was built principally for mining interests.) SNEL stated to the NRECA team that it recognizes the need for small hydroelectric systems in isolated, rural areas, and it sent a technician with the team to visit sites in the Bas-Zaïre region. It has a technical staff, but in the past has relied primarily on outside consultants for

\(^1\) Background Notes, Zaïre, U.S. Department of State, June 1978.
technical studies. This is believed due to the relative inexperience of its staff and to lack of operating budget and equipment.

**PLAN**—This ministry controls the use of local currency on projects and is responsible for coordination of donor activities. It will have a key role, perhaps in conjunction with the United Nations Development Program (UNDP), in enlisting support of other donors for this proposed SHREP.

**Special Presidential Study Group (SPE)**—This group is attached to the office of the president and is responsible for investigating special development projects. It includes a number of well-trained but inexperienced engineers. With SNEL, it recently compiled a list of potential small hydroelectric sites (see list of sites in appendix E). The technical assistance group under this project should collaborate with SPE and SNEL in the initial screening and assessment of such projects and in related longer range energy studies.

Other organizations with special interest in energy development in Zaire:

**Constructeurs Inga Shaba (CIS)**—A key element in this consortium is the U.S. firm of Morrison-Knudsen, which is constructing the Inga-Shaba Transmission Line (an approximately million-volt d.c. line). Over a period of several years, CIS has built up a considerable capacity for construction, engineering services, and procurement from U.S. sources. CIS operates laboratories for soils and materials testing that could provide services on a reimbursable cost basis to this project.

**U.S. Water and Power Resource Service (WPRS)** (WPRS has recently reverted to its old name, Bureau of Reclamation)—Engineers from this agency could assist USAID in the SHREP by refining the scope of work for future resource-inventory and power-load studies and by monitoring progress on the USAID-assisted projects. This would probably require a negotiated AID-WPRS PASA agreement, since WPRS is under direct contract with the government.

**Peace Corps**—At numerous locations, this organization is a potential local source of people experienced in small self-help construction of the type to be encountered at most subprojects under the SHREP.

**Religious missions**—Many Catholic and Protestant groups (including one denomination, Kimbanquist, unique to Zaire) operate schools and hospitals in isolated rural areas of Zaire. A few of these missions operate small hydroelectric systems that they planned and built themselves, in some cases many years ago. Others have requested assistance from USAID to plan and install small hydro-systems to fulfill their power requirements.

**National Rural Electric Cooperative Association (NRECA)**—The producer of the present study, this organization has considerable international experience in construction of rural electric systems.
and in related institutional development. It could provide specialists to carry out resource inventories, load forecast studies, site planning, or other studies involved in rural electrification.

Volunteers in Technical Assistance (VITA)—This organization specializes in technology adaptable to developing countries. VITA's personnel are knowledgeable about small hydropower development and could provide valuable technical services in this project. These services could include design or supervision of systems of less than 50-kW capacity.

Local individuals and institutions with engineering or construction capability—Probably not an extensive resource pool, local individuals and institutions should be recruited as widely as possible. In addition to their technical contributions, their knowledge of local conditions could prove invaluable.
The government recognizes the requirement for additional energy development. The development of small hydropower sites, particularly those that replace diesel-fueled plants, is now one of the government's chief priorities.

Many isolated rural areas of Zaire have no access to existing or planned transmission lines. The government has listed several sites that it wants to develop (appendix E) and USAID has received at least 13 requests for grant assistance in developing small hydro-electric systems at various missionary operated hospital/village/school complexes in different parts of Zaire. Locations of these complexes are shown in appendix C, figure 1.

Power is needed for certain hospital equipment (X-rays, pharmaceutical laboratories, etc.), water supply, lighting of homes and schools, and often for operation of small grain mills or other agricultural equipment. This power is, in practical terms, unavailable for many needs at present because gasoline and diesel supplies are uncertain and extremely expensive. In addition to saving scarce foreign exchange that now goes to purchase diesel fuel, the availability of more hydropower would curtail the present rate of deforestation since wood is an important energy source in Zaire and, without increased hydropower, is likely to be used more in the future. The government is even considering the possibility of rehabilitating old wood-burning steam engines to generate electricity.

Zaire's energy requirements can be met only by addressing some of the critical needs involved in energy development:

The need to increase the capabilities and performance of institutions

Energy development will require institutional development of local implementing and user organizations as well as local and national government departments. Any program aimed at developing hydropower should include an institutional development element. As in many underdeveloped countries, there are weaknesses at every level in these institutions. A lack of complementary infrastructure adds to the difficulties of construction and operation.

The need for planning

The government needs assistance in planning for the development of increased availability of electricity, particularly in rural areas. Many local missions and villages have some self-help resources, but all need some technical and financial assistance to plan and develop potential sites. The government is generally unable to provide this assistance.
The government should also be assisted in its development of a complete energy inventory and in its planning for an integrated national power grid. Alternative energy sources (wood, geothermal, solar, etc.) should be quantified. Significant resources should be devoted to developing forecasts of future energy requirements, and to planning the electrification of rural areas by developing local hydropower, and alternative energy sources, and by establishing an interconnected electric system.

The need for training

Since very few Zairians are trained in these technologies, especially small hydropower technology, the government needs assistance in training its citizens to plan, construct, operate, and maintain power systems. Probably the most needed kind of training at all levels is practical, on-the-job work experience. This could be provided under the SHREP project by having Zairians work with experts financed by the project.

The need for program development

There is a need to plan a sound, long-term energy development program to allow optimum use of all the potential energy resources. This plan should make maximum use of Zaire's financial, natural, and human resources, and should enlist support from international lending and donor sources to meet critical gaps where they occur. Increased coordination within the government and with international donors is necessary in order to reach a consensus on how energy development should proceed and on the roles of all parties involved.

The need for financing

Potential load centers, many of which are missionary-operated school/hospital complexes, have different amounts of financial and technical resources available to them. Some are fortunate enough to have resident engineers or managers with valuable experience and have financial supports in the United States. Others have very little in terms of the skills and financial resources needed to develop their sites. Technical and financial assistance under this proposed project would supplement these resources where site potential and benefits would justify the assistance. Suggested criteria for establishing priorities of subprojects are set forth in appendix B.

5 Type of assistance required in small hydropower development
Option A: Full multidonor program

The SHREP Option A, as described below, involves multidonor participation. It includes some elements that could be reduced or deferred if necessary because of funding constraints or for other reasons. However, Option A is recommended on the basis of both need and feasibility.

A coordinated and comprehensive intervention

The full SHREP option assumes that donor participation sufficient to support a 5-year comprehensive project costing some $55 million could be mobilized. Intervention on this scale would have economies of scale not possible in smaller, scattered assistance projects and would lead to sounder long-range planning for resource development.

This option addresses all of the factors discussed above as essential to the needed energy development—improvements in institutional performance, energy-related planning, training, energy program development, and financial assistance to Zaire through loans or grants provided by participating donors.

Demonstration and pilot sites

Under Option A, some funds would be available for development of selected subprojects. These would be subprojects determined to have highest priority for immediate construction under a ranking formula presented in appendix B. These subprojects would also serve as demonstrations of typical small hydro systems, as centers for the on-the-job training of technicians and system operators, and as pilots providing experience to be applied in the planning of other subprojects.

Skills required

The skills required for planning and developing small hydro systems can be briefly summarized according to the general activity or phase of work:

Planning phase. Engineering skills required for planning and design of small hydropower projects are civil and electromechanical.

The economic analysis required to evaluate the feasibility of subprojects may be done by a specialist or by an engineer trained in project economic analysis, including hydroelectric projects.

Construction phase. Engineers are needed to monitor or advise on construction.
Craftsmen—carpenters, masons, equipment operators, machinists and mechanics, pipefitters, electricians, welders, drivers, surveyors, and geotechnicians (geologists) are required in this phase.

Operation and maintenance phase. Technicians trained in the operation and maintenance are essential in this phase.

Technical assistance

All members of the core technical assistance team provided for under Option A should have a good knowledge of the French language and work experience in developing countries. The following professional skills should be represented on the team.

Civil engineering. Civil engineers should have experience in design and construction of water control structures and of small buildings; knowledge of hydrology (water supply and flood estimation) and of turbine selection and installation; and general knowledge of environmental impact assessments are also important. Civil engineers will be required for the duration of the project.

Electromechanical engineering. These specialists should be experienced in the design and construction of electrical systems and have knowledge about the generation, control, and transmission of power from small hydroelectric systems. The services of these specialists will be required for 25 months.

Economic and social soundness analysis. These team members will provide analysis of social and organizational factors that will affect social and financial viability of the subprojects. Their services will be required for about 30 months.

Administrative/logistical support. Ideally a citizen of Zaire, the person in this position should have broad administrative and logistics experience in Zaire. His main function will be to manage routine administrative and logistical aspects of the project, so that other specialists can function effectively in their areas of expertise without the burden of logistical or administrative concerns. Administrative and logistical support will be needed for the duration of the project.

Miscellaneous specialized skills. Some specialized expertise not specifically identified at this time should also be provided in the technical assistance project contract. This specialized expertise will be required for about 5 months.

The NRECA recommends that technical assistance for this project be provided through a USAID contract with an organization that can supply both the necessary technical skills and the home-office support. The latter is particularly important when specialized services are required—for example, designs of long penstocks or resolution of hydraulic or electrical problems beyond the capability
of a resident staff. Home-office support of a firm with international experience may be particularly useful in providing solutions to tricky problems gained through relevant experience in other countries. Should USAID choose not to rely on a single organization for this project, it could recruit the necessary personnel and organize the team itself. This course is not recommended. The team should be responsible to AID and should schedule its work, under AID direction, to benefit the government agencies (SNEL in particular) and private volunteer organizations (PVOs).

In addition to planning, designing, and constructing small hydro-systems, Option A provides that the core technical assistance team perform additional tasks essential to national optimal energy development. Option A calls for the funding of short-term consulting services to assist the core team in these duties, which include—

(a) Developing an inventory of potential energy sources by type (for example, hydro, biogas, and geothermal—with emphasis on hydro), location, and potential capacity

(b) Preparing forecasts of energy/power demands at production or population centers

(c) Providing assistance to the government in planning future facilities for power transmission/distribution, especially to and from isolated rural areas

(d) Demonstrating to energy user groups how to set up cost repayment programs and operate their systems

(e) Making specialized technical, management, socioeconomic, and environmental studies needed for rural electrification.

Included in this project must be an evaluation of Zaire's energy development policies and potential staffing capabilities. This evaluation could be executed either by the NRECA or by an independent specialist in administrative and organizational development. The study should be made in collaboration with appropriate USAID officers. This analysis is necessary in order to plan a satisfactory training and work-learning program for government officials.

**Procurement**

Procurement is a time-consuming problem in many development projects in Zaire. Delays with exoneration procedures, errors in specifying equipment and materials, difficulty with transportation, and simple bureaucratic procrastination often result in severe cost overruns as scheduled work becomes impossible.

Constructeurs Inga Shaba has the organization and capability for rapid procurement that could be used to good effect in the SHREP.

8 Option A: Full multidonor program
This would probably require negotiation of a contract to reimburse CIS for costs associated with procurement services, but of the possible methods of procurement it seems the best.

**Donor coordination for SHREP**

It is important that donors collaborate closely in the planning and construction of small hydroelectric systems. Such collaboration could produce economies of scale not available to each donor individually and present development schedules that may be incompatibi-le or uneconomic.

**Suggested duration (project life) SHREP**

The life of this project should be at least 5 years for the following reasons:

Development of power supplies in isolated rural areas is a task that will continue for decades because of the large potential for development, great needs, and the very underdeveloped state of the rural Zairian economy.

The time required to develop subprojects from initial conception to operation is likely to be 3 to 5 years, considering time required for investigation, design, approvals, procurement, training, and installation/construction.

Certain activities are intrinsically long-range (for example, inventory of sites for hydropower, study of alternative energy sources, training of higher-level technicians). Too short a timeframe would not allow for the production of tangible results from such project activities.

AID policy and procedures will permit a 5-year project life.

A longer timeframe may not be advisable since a thorough project evaluation should be carried out as soon as is practical.

**Budget for SHREP**

Technical assistance required for the project is estimated as follows:

<table>
<thead>
<tr>
<th>Salaries</th>
<th>Thousand dollars</th>
</tr>
</thead>
<tbody>
<tr>
<td>Civil engineer/hydraulic engineer--60 months</td>
<td>240</td>
</tr>
<tr>
<td>Electromechanical engineer and short-term specialists--30 months</td>
<td>120</td>
</tr>
<tr>
<td>Economist (socioeconomic)--30 months</td>
<td>120</td>
</tr>
<tr>
<td>Administrative/logistical assistance--60 months</td>
<td>120</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Other costs</th>
</tr>
</thead>
<tbody>
<tr>
<td>Subsistence</td>
</tr>
<tr>
<td>Office rental (or supplied by SNEL)</td>
</tr>
<tr>
<td>Supplies and subcontracts</td>
</tr>
<tr>
<td>Firm overhead</td>
</tr>
<tr>
<td>Firm profit</td>
</tr>
</tbody>
</table>

9 Option A: Full multidonor program
International travel 150
In-country travel 150
Short-term consulting services as required 870
Total 3,000
or $3 million

Immediate impact assistance. NRECA recommends that $7.5 million plus Z 22.5 million be allocated, over the 5-year project life, for assistance to selected subprojects, well advanced in conception, and under 1/2 MW in capacity. The government contribution of local currency to the project should be negotiated with PLAN. This sum should be adequate to fund the full technical assistance contract and provide grant assistance to several small subprojects. (Total $15 million)

Medium and long-term assistance. The NRECA suggests that $20 million over the 5-year project life, plus an approximately equivalent amount of local currency, be allocated for what is primarily the procurement and construction cost of the project. (Total: $40 million)

Total project cost. Total Option A project cost, $55 million.

Other considerations. Some technical assistance should, if possible, be provided under existing USAID authority, without waiting for formal approval of the project paper. This would facilitate preparation of the necessary Project Implementation Document (PID) and Project Paper (PP) by USAID.

Roles and contributions to the project

Noted below are the organizations which, under Option A, will be involved in the project and the roles of each:

SNEL. This organization would provide counterparts to work in conjunction with technicians supplied by the project. The project would provide training in energy-related subjects to select SNEL staff members.

DOE. This department would review and approve applications for hydroelectric projects and would collaborate with the project technical assistance team in the inventory of energy resources, power level, forecasts, and matters relating to the development of energy policy.

PLAN. This ministry, which controls use of local currency, would dispense necessary funds to the project. It would be responsible for donor coordination. It would play a key role with UNDP in enlisting support or other donors for the SHREP project.

SPE. This group would collaborate in the national inventory of energy resources and site feasibility studies.

10 Option A: Full multidonor program
**USAID.** USAID would assist in the financing of the SHREP, monitor the project, and provide technical assistance and training. USAID would also attempt to enlist the support and participation of other donors by encouraging the formation of a donor coordinating committee.

**NRECA.** This agency could provide short-term technical assistance for such specialized studies as: resource inventories, energy requirement forecasts, productive use plans, and management administration analyses needed for small hydro and rural electrification.

**USWPRS.** This service, which has civil and electrical engineers in Zaire, would advise and assist USAID in formulating the SHREP project and in monitoring progress on subprojects.

**U.S. private sector.** Many U.S. firms have experience in hydroelectric development. Some would be called on to provide the long-term technical assistance required in the SHREP. At least one American firm, International Engineering Company (a subsidiary of Morrison-Knudsen), has done some preliminary investigation of hydroelectric sites in Zaire.

**VITA.** The publications of this organization would provide useful information on microhydropower technology, and its personnel would serve as a potential source of supervisors and advisors for self-help construction projects.

**Peace Corps or International Voluntary Services.** Both of these organizations are experienced in self-help construction and would be potential sources of supervisors or advisors for small hydro construction.

**PVOs.** These organizations would receive the chief benefits of the project. With the SHREP assisting them, they would carry out much of the planning, implementation, and operation of the project.

**ECZ.** This group represents the missionary PVOs in Zaire. Most procurement would be channeled through it since it has exoneration from duties not enjoyed by individual PVOs. The ECZ also has technical capabilities that the project would utilize.

**Local firms and individuals.** Local firms and individuals with engineering and/or construction skills would be used as widely as possible.

**MAF.** The Missionary Air Fellowship would provide air service to many of the hydro sites. It would be important in local transport of technicians and some supplies and equipment.

**Training**

The USAID human resources development officer should collaborate with the government and the technical assistance team to develop training plans in detail. The general categories of training are--
On-the-job training for craftsmen and technicians. On-the-job training is recommended for the learning of construction skills (carpentry, masonry, topographic surveying, concrete work, machine shop work, equipment operation and maintenance). This training would be provided for PVO members and government staff.

NRECA also recommends that consideration be given to training a small group of craftsmen and subprofessional technicians who could be moved to job sites as needs occur.

Certain skills (welding, pipefitting, for example) may be needed only rarely at some sites. Since it would be neither economical nor practical to train local people at sites for these skills, NRECA suggests the creation of a mobile team of craftsmen and "trouble-shooters" who could be within the SNEL organization. This team would be able to assist small power stations with operational problems as well as with initial construction.

Resident power site operators should be trained at a similar existing plant and receive on-the-job supervision at the site of permanent assignment. The SHREP electromechanical engineer should assist in design and presentation of training for powerplant operators.

Counterpart training for engineers and economists. Counterpart training through the association of government professionals with the project engineers and economists is advocated. This training would include planning and development of sites, power load forecasts, alternative energy evaluation, and hydropower site inventories.

Participant training for selected government professionals. Participant training for a few government professionals from DOE, SNEL, or SPE is suggested. This should include training at the postgraduate level in energy-related topics. The budget for participant training would be on the order of $1 million, subject to further study as the recommended management analysis is made of the government, its staff, and its functions.
**Implementation schedule**

An appropriate implementation schedule is shown below:

<table>
<thead>
<tr>
<th>Step</th>
<th>To be completed by end of month—</th>
</tr>
</thead>
<tbody>
<tr>
<td>PID prepared</td>
<td>2</td>
</tr>
<tr>
<td>PP design team recruited</td>
<td>3</td>
</tr>
<tr>
<td>PP prepared</td>
<td>6</td>
</tr>
<tr>
<td>Donor coordinating committee formed</td>
<td>6</td>
</tr>
<tr>
<td>PP reviewed and approved</td>
<td>7</td>
</tr>
<tr>
<td>Technical assistance team for project recruited</td>
<td>15</td>
</tr>
<tr>
<td>Project implementation begins for immediate impact program</td>
<td>16</td>
</tr>
<tr>
<td>Project implementation begins for medium and long-term impact program</td>
<td>16</td>
</tr>
<tr>
<td>Project evaluated (annually)</td>
<td>28, 40, 52, 64, 76</td>
</tr>
<tr>
<td>End of project</td>
<td>76</td>
</tr>
</tbody>
</table>
Alternative options for consideration by USAID

**Option B**

Option B is derived from Option A by deleting $20 million in procurement and construction costs. Institutional development, training, and planning elements (all of which seem necessary for a viable project of any scale) are not reduced. Total project cost would be approximately $35 million. This option might be attractive to donors since it retains significant elements of construction and procurement, and carries out other activities that donors would probably consider essential for a sound project.

A major drawback of Option B might lie in the underutilization of the technical assistance group. Because the size and makeup of the group as outlined in Option A represents an irreducible minimum of project expertise, the diminution in project scope under Option B would lessen the utilization of this very valuable team.

**Option C**

Option C includes all elements of Option B except that construction and procurement costs would be limited to about $12 million. This is the amount considered needed in Option A for high-priority selected small subprojects (under ½ MW). Option C would include the full technical assistance components of Option A. Thus the issues of institutional development, training, and planning of some rural electrification could still be addressed. Cost of Option C would be $15 million.

**Option D**

In addition to the deletions made in Options B and C, Option D would delete or defer that portion of the project's technical assistance not directly required for the immediate impact element. Savings of perhaps $1 million might be possible by deferring items such as the inventory of hydro sites and the supplemental assistance for long-range studies and planning, although it should be recognized that these needs must be met at some point. In short, these items could be deferred at a sacrifice to the speed and cost-effectiveness of energy development. Total cost of Option D would be $14 million.

**Option E**

Option E is essentially a continuation of USAID's present approach of undertaking no significant new energy development initiatives except those that can be handled by the present USAID staff or by the very limited technical assistance available without approval of a project. Even under a "no new initiative" approach, we believe USAID will need increased engineering and economic analysis capability to assist it with energy-related studies and with monitoring.
of the Karawa Hydroelectric Project, which is already under construction. Under Option E, USAID's engineering needs would be met through the addition of a staff engineer and through short-term assistants employed on an as-needed basis.

Table 1 summarizes the options discussed above.

<table>
<thead>
<tr>
<th>Increment/component</th>
<th>Option</th>
</tr>
</thead>
<tbody>
<tr>
<td>Technical assistance for institutional development, training, and subproject planning/supervision</td>
<td>+ + + + TA reduced to $0.30 million</td>
</tr>
<tr>
<td>Supplemental TA for mid- and long-term planning (resource inventory, rural electrification, alternative energy source)</td>
<td>+ + + 0 0</td>
</tr>
<tr>
<td>Immediate impact assistance in procurement/construction of selected small projects ($12 million)</td>
<td>+ + + + Reduced to $1 million</td>
</tr>
<tr>
<td>$20 million procurement/construction (first increment)</td>
<td>+ + 0 0 0</td>
</tr>
<tr>
<td>$20 million procurement/construction (second increment)</td>
<td>+ 0 0 0 0</td>
</tr>
<tr>
<td>Cost (million $)</td>
<td>55 35 15 14 1.5</td>
</tr>
<tr>
<td>Key: + included 0 excluded</td>
<td></td>
</tr>
</tbody>
</table>

15 Alternative options for consideration by USAID
Appendix A

Scope of Work

General

USAID invited an NRECA technical assistance team to Zaire to aid in outlining a strategy for rural mini-hydropower development in Zaire. Although hydropower development has a top priority rating in the country, the government has not yet produced a strategy for executing its energy policy goals. Thus, the work the TA team was charged with could benefit both USAID and the government in establishing the boundaries within which appropriate project development could be undertaken.

Trip agenda

USAID requested that Robert Thornbloom, manager of an AID-assisted rural hydropower project in Zaire's northern equator region, accompany and assist the TA team. Thornbloom is familiar with the characteristics of many potential hydropower sites around Zaire and has performed some preliminary surveys of specific site potential.

The team was to spend its first week in Kinshasa discussing rural hydropower policy, experience, potential, and options for institutional responsibilities in project development. As a part of this orientation process, the team was to meet with interested organizations including the Department of Energy, the National Electricity Company, the Presidential Studies Service, the National University, and the Ecumenical Church of Christ in Zaire. Meetings were also planned with multi- and bi-lateral donor agencies that might become participants in a national rural hydropower development program.

During the following 10 days the technical assistance team was to visit potential hydropower sites around the country. During these visits the team was to form preliminary assessments of site suitability and to identify the additional work needed for complete assessments. Upon its return to Kinshasa, the team was to prepare its final report to the mission and conduct any follow-up meetings necessary.

Outputs

The team was to focus particular attention on the following concerns:

Criteria for site selection
Criteria for rank-ordering potential projects by priority
Proposed institutional mechanisms to employ AID and other donor assistance
Suggested roles and contributions to project development of government agencies and project beneficiaries
Identification of standard equipment for possible projects
Guidelines of cost-estimating projects, benefits
Specification of skills required for both facilities installation and operations
Suggested training programs to address identified needs.

Relevant comments and suggestions by team members were also solicited.
Appendix B

Project guidelines

1. Criteria for site selection

This set of criteria for selecting sites for further consideration is based on the analysis of data and information provided in requests received by AID, on site visits, and on discussions with government officials and private volunteer organizations.

Social and economic impact. This should be measured in terms of population, capacity of schools, medical facilities, commercial enterprises, and agroindustrial facilities to be served.

Existing availability of electric power. Consideration should be given whether hydroelectric power is the best alternative for meeting electrical energy requirements of the area. The areas or load centers within 10 kilometers of the transmission grid (existing or under planning by SNEL) should be ruled out from consideration unless it is impractical to tap such existing lines (as when stepdown transformers would be too costly or incompatible with the major system).

Potential power. The electrical potential at site should be considered in terms of both capacity (kW) and energy (kWh). Sites where water resources exist but where the electrical potential is very low or unreliable due to seasonal flow fluctuations should be eliminated from consideration.

Head available. A minimum head available at site should be set to eliminate consideration of sites that have sufficient water resources but lack of sufficient available head to permit economically feasible development. A head of less that 3 meters will probably be impractical to develop.

Compatibility with government regional development plan. Each site should be checked for compatibility with the development program of the government. Certain agricultural production centers receive a high priority for development from the government.

Environmental impact. An assessment of environmental impact due to the development of the site should be made. For most small hydro sites environmental impacts should be low.

Distance to load centers. The distance of the site from load centers would determine the need for transmission lines. Very long lines serving a small load are not practical.

Geological condition. Geological condition at site should be assessed by field visit.
Availability of skills. Consideration should be given to the employment of local workers to construct, operate, and maintain the hydroelectric plant.

Donor check. A full financial check should be made at each site to ensure that all donor involvement is known. USAID would provide grant assistance directly to PVO or other qualified local groups after approval by SNEL or other appropriate government agencies and after certification of soundness by the technical assistance team. This team would certify technical, economic, environmental, and social soundness.
2. Criteria for rank-ordering potential projects by priority

Four methods are proposed for use in ranking potential projects. Each method provides a systematic way to assign priorities to projects according to level of studies available.

U.S. Corps of Engineers Method.*
(*Water Resource Assessment Methodology—Impact Assessment and Alternates Evaluation, R. C. Solomon et al, U.S. Army Waterways Experiment Station, 1977.) This method could be used to rank projects which were identified by level and were passed through the first screening using the criteria for site selection described in Section VII of Solomon's manual.

A modified method is proposed as follows, with an example shown in Table 2.

Suppose there are four projects, A, B, C, and D to rank–order by priority and in number of criteria in site selection.

a. Each criterion in site selection will be assigned a weight according to its importance at the site by the team. To facilitate computation, the combined weight of all criteria (in each project) could be made to equal one:

\[ C_1 + C_2 + C_3 + \ldots + C_n = 1.0 \]

b. The projects will be ranked according to each criterion, and a score will be given to each project. The highest score will be given to project that ranked first (highest) and the lowest score will be given to project ranked last (lowest). For instance, scores of four, three, two, and one could be given to projects ranked in order first, second, third, and fourth.

c. The weighted score of each project in a criterion will be obtained by multiplying the weight of the criterion \( C_n \) by its score.

d. By adding up the weighted scores for each project its total score will be obtained.

e. The priority ranking will be done by observing the weighted scores. The project with a highest score will be considered to have a highest priority.
Table 2

<table>
<thead>
<tr>
<th>Criteria</th>
<th>Project Score, $s^{1/}$</th>
<th>Weighted Score</th>
</tr>
</thead>
<tbody>
<tr>
<td>$C_n$</td>
<td>$A$ $B$ $C$ $D$</td>
<td>$A$ $B$ $C$ $D$</td>
</tr>
<tr>
<td>$C_1$</td>
<td>0.2 2 1 3 4</td>
<td>0.4 0.2 0.6 0.8</td>
</tr>
<tr>
<td>$C_2$</td>
<td>0.5 3 1 4 2</td>
<td>1.5 0.5 0.2 1.0</td>
</tr>
<tr>
<td>$C_3$</td>
<td>0.4 4 3 2 1</td>
<td>1.6 1.2 0.8 0.4</td>
</tr>
<tr>
<td>$C_4$</td>
<td>0.1 1 2 3 4</td>
<td>0.1 0.2 0.3 0.4</td>
</tr>
<tr>
<td></td>
<td>1.0</td>
<td>3.6 2.1 1.9 2.6</td>
</tr>
</tbody>
</table>

$1/$ Four is the highest score and one is the lowest score.

In this example the projects will be ranked as follows:

<table>
<thead>
<tr>
<th>Rank Ordering</th>
<th>Projects</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>A: 3.6</td>
</tr>
<tr>
<td>2</td>
<td>D: 2.6</td>
</tr>
<tr>
<td>3</td>
<td>B: 2.1</td>
</tr>
<tr>
<td>4</td>
<td>C: 1.9</td>
</tr>
</tbody>
</table>

Project A is the most attractive and C the least attractive according to this ranking criterion.

**Construction cost per kilowatt.** If the project were developed to the point where cost estimates could be made with generally equal degrees of accuracy, construction cost per kW of capacity could be used as a rank-ordering procedure. This should not be the sole criteria for ranking, because it ignores other important factors.

**Electricity cost per kilowatt hour.** When the average amount of electrical energy to be generated and the cost of the money to finance the project (interest rate and method of amortization) are known, the total annual cost of the project can be estimated. This estimate should include investment as well as operating and maintenance costs. With this knowledge, cost per kWh can be computed. The projects could then be ranked by its cost per kilowatt hour. Again, this should not be the sole ranking criterion used.

**Benefit/cost analysis.** Costs of, and benefits generated by the projects should be estimated in order to perform a benefit/cost analysis. The benefits could be taken as the costs of providing electricity to the project beneficiaries who do not have the next best alternative. This alternative would vary according to several factors. The projects having the highest benefit/cost ratio will be ranked with highest priority.
In developing benefit/cost ratios, analysis can attempt to quantify social and environmental costs and benefits, but this introduces complexity, uncertainty, and (probably) controversy. Nevertheless, benefit/cost ratios serve as an important and widely used method of ranking.

The use of a combination of criteria has an advantage over purely judgmental ranking: it generally provides a rational basis for decision that is, at least somewhat, removed from political or other pressures in project selection.
3. Standardization and simplification of equipment

**Turbine/generator units.** Developing standardized turbine/generator packages that could be installed economically at potential Zairian micro-hydropower sites would be very difficult, at this stage of the project. Standardization would require an inventory of potential sites not now available and complete U.S. manufacturers' information on available standardized turbine/generator units. The existing list of sites is not comprehensive and gives no details. Standardization of models of turbines/generators is made even more difficult by the varied conditions at sites for which sufficient data is available to size units. Despite these obstacles, a number of European and North American manufacturers of hydraulic turbines are presently, or are considering developing standardized equipment designs for small hydroelectric installations. In some instances, these efforts have been expanded to cover complete equipment packages, including such items as the turbine, generator, speed increaser, flywell, governor or blade positioner, intake water control valve, generator excitation, controls, breakers, and transformers. In these cases, items of equipment secured from a variety of manufacturers are interfaced by the major manufacturer and assembled to form the complete package.

**Electrical equipment.** Standards should be set by SNEL for the distribution voltage level and for the equipment used in the electrical distribution system. This will reduce the overall engineering design, spare parts, and inventory costs of integrating isolated systems, and will encourage the in-country manufacture of distribution.
Summary of available data on standardized turbine packages

This list is illustrative and does not include all manufacturers.

<table>
<thead>
<tr>
<th>Turbine type</th>
<th>Manufacturer</th>
<th>Head range (feet)</th>
<th>Flow range (cfs)</th>
<th>Capacity range (kW)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Propeller</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Right-angle drive, fixed blades</td>
<td>Hydro-Energy Systems (Neyrpic)</td>
<td>6-60</td>
<td>35-750</td>
<td>100-1500</td>
</tr>
<tr>
<td>Tubular, horizontal</td>
<td>&quot;</td>
<td>8-60</td>
<td></td>
<td>500-5000</td>
</tr>
<tr>
<td>Bulb, Kaplan</td>
<td>&quot;</td>
<td>8-60</td>
<td>175-2500</td>
<td>100-5000</td>
</tr>
<tr>
<td>Tube fixed or adjustable blade</td>
<td>Allis-Chalmers</td>
<td>7-50</td>
<td>100-1600</td>
<td>100-6000</td>
</tr>
<tr>
<td>Vertical axial flow</td>
<td>&quot;</td>
<td>27-50</td>
<td>100-1600</td>
<td>100-6000</td>
</tr>
<tr>
<td>Mini tube, fixed blade</td>
<td>&quot;</td>
<td>6-40</td>
<td></td>
<td>25-1000</td>
</tr>
<tr>
<td>Tubular, vertical</td>
<td>KMW</td>
<td>7-80</td>
<td>35-270</td>
<td>100-1500</td>
</tr>
<tr>
<td>Tubular, vertical</td>
<td>Tampella</td>
<td>10-80</td>
<td>30-350</td>
<td>100-3000</td>
</tr>
<tr>
<td>Conventional, vertical</td>
<td>Barber</td>
<td>10-20</td>
<td>18-200</td>
<td>13-230</td>
</tr>
<tr>
<td>Conventional, horizontal</td>
<td>Barber</td>
<td>10-50</td>
<td>21-420</td>
<td>15-1500</td>
</tr>
<tr>
<td>Francis</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Conventional, horizontal</td>
<td>Barber</td>
<td>15-200</td>
<td>17-550</td>
<td>18-4100</td>
</tr>
<tr>
<td></td>
<td>Gilberg Gilkes &amp; Gordon Leffel</td>
<td>10-600</td>
<td>14-140</td>
<td>10-6000</td>
</tr>
<tr>
<td>Conventional, vertical</td>
<td>Barber</td>
<td>10-50</td>
<td>17-450</td>
<td>13-4100</td>
</tr>
<tr>
<td></td>
<td>Gilbert Gilkes &amp; Gordon Leffel</td>
<td>10-600</td>
<td>14-140</td>
<td>10-6000</td>
</tr>
<tr>
<td>Impulse</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Hydec, Turgo</td>
<td>Gilkes, Border Contractors</td>
<td>40-300</td>
<td></td>
<td>5-300</td>
</tr>
<tr>
<td>Crossflow</td>
<td>Ossberger/ Stapenhorst</td>
<td>3-660</td>
<td>1-320</td>
<td>3-1000</td>
</tr>
<tr>
<td>Pelton</td>
<td>Small Hydro-electric Systems &amp; Equipment</td>
<td>40-600</td>
<td>1-100</td>
<td></td>
</tr>
</tbody>
</table>
4. Guidelines for cost estimating

The cost estimates for subprojects should proceed through three stages from least detailed, screening estimates to final preconstruction estimates:

Prefeasibility screening estimates. Cost information from similar projects, which is generally available from government sources and from local contractors, provides a useful framework for an order of magnitude estimate made by a qualified engineer. This preliminary estimate will provide approximate costs of the project and its cost relative to other systems. This information, coupled with preliminary estimates of benefits, can be used in deciding whether to proceed with further study and more detailed estimates. Care must be taken to adjust cost data to current local conditions or the results can be meaningless. Constructeurs Inga Shaba and the builders of the Karawa Project should be useful sources for cost data at this stage.

Feasibility estimates. These are "reasonably firm" estimates based on preliminary layout drawings of the construction work and unit quantities of excavation, materials, and approximate equipment costs. (The term "reasonably firm" is used in the Foreign Assistance Act, Section 611, which applies to AID-financed capital projects.) These estimates should come within 25 percent of actual final costs unless unforeseeable events intervene. A contingency allowance is provided for unforeseeable events. The USAID Cost Estimating Manual contains procedures recommended in making feasibility estimates. Feasibility estimates are used, of course, in determining project feasibility, and in determining the amount of project funding required. They are basic data required for authorization and should be made by a qualified engineer.

Final preconstruction estimates. These estimates must be made in detail and with due consideration for the equipment to be used, local labor cost and productivity, and a schedule of procurement and construction. This requires thorough planning and complete, detailed design of the system since the estimates ordinarily will be the basis of construction contracts. Equipment costs should be based on quotations from the supplier. The estimates and the designs and plans on which they are based should be made only by a qualified engineer.
5. Guidelines for determining economic feasibility

An economic analysis should be performed to determine the economic feasibility of each subproject. This involves making estimates of benefits as well as costs of the project. Appendix B4 deals with estimates of costs at different study levels, in this section a procedure for estimating benefits is outlined. Also discussed here is the power market analysis necessary for planning a hydroelectric project. For many very small hydropower projects in isolated areas the analysis would be quite simple.

Power market analysis

Power market. A survey should be made to determine the following:

1. The number of present consumers by classification (residential, commercial, industrial, government, school, hospital, etc.); the power demand (kW) and consumption (kWh); past and estimated future rate of growth for each category.

2. The requested or potential service to large or special consumers.

3. Forecast of future kW demand and kWh energy requirements properly related to historical and present demand and energy requirements.

4. System characteristics such as frequency, phase, voltage, hours of service per day, etc.

5. Typical expected daily load patterns for annual peak and minimum demand periods when project goes into operation and when project fully utilized.

6. Present power use or market surveys, studies, or reports.

Present power systems. The existing availability of electric power should be described, and it should include the following:

1. A brief description of the service area, illustrated by maps and diagrams, showing present and planned transmission and distribution systems as well as the location of each power source, major substation, switching point, and interconnection with other systems.

2. A description of the existing facilities that now provide, or are able to provide, electric power supply, transmission, and distribution services in the area, giving capacity, capability, and reserves of each system. The description should include list of plants and major power substations, showing ownership, purpose served, condition, and age.

3. A description of operating problems such as low voltage, insufficient capacity, low reliability, excessive outage, and other inadequacies of the present systems (lack of fuel, transportation of fuel supply).

26 Appendix B
4. A summary of current planning in support of, or in conflict with, the proposed system.

5. A description of major units of present systems including generating plants, transmission system substation, and distribution systems.

Plan for meeting future requirements. The long-range study should show how forecasted power requirements will be met by the proposed project. This study should demonstrate how the proposed project will be integrated into the existing system. The study should include—

1. An estimate of the benefits based on contrasting estimates of the costs of providing power and energy from the most favorable alternative. This alternative could include the installation of diesel generator or connection to the distribution grid planned by SNEL.

2. An economic evaluation made by comparing the power supply projects, with hydroelectric plant and without hydroelectric plant but with the alternative power supply, on the basis of benefit-cost (B/C) ratio. The costs of the project with hydroelectric plant should include costs for construction, operation and maintenance, and administration. The method of establishing benefits is discussed above, and should include costs of construction, operation and maintenance, fuel, and administration of the project. The hydroelectric project having a B/C ratio greater than unity will be considered attractive.

The B/C ratio of projects could be used to rank-order potential projects by priority as discussed in Section B2. However, it should not be the sole ranking criterion.

Although this economic analysis may seem somewhat complicated, it can be accomplished very quickly and easily with a few calculations. The important things to understand are that—

1. The comparative cost of an alternative power source must be considered, as a basis for estimating the benefit of a hydroelectric system.

2. Operational and maintenance costs and equipment life must enter the calculation.

3. Once the procedure is established for one or two small hydroelectric systems, it can readily and easily be adapted to others.

Thus, rather than a complicated analysis impractical for small power systems, the NRECA team recommends a relatively simple procedure that should meet requirements.
6. Appropriate standards for project planning

Planning small hydroelectric projects calls for the determination of the degree of acceptable risk. Very small systems in which failure would not result in loss of life or serious property damage will, in general, require less exacting and less expensive engineering and construction.

Feasibility studies and engineering design ordinarily should be held to a reasonable percentage of anticipated investment costs (perhaps 25 percent would be reasonable in Zaire). Since most small hydro developments have minimal adverse impact, the 25 percent figure should permit the making of feasibility studies that include the necessary soundness analysis of environmental and social impact.
Appendix C

Preliminary assessments of sites

The following 13 sites are those for which some information is available, and for which requests for USAID assistance have been made:

Sona-Pangu
Sundi-Lutete
Rwanguba
Koda Hydroelectric, Retshi
Ngombe-Matadi
Nkamba
Sona-Bata
Tshabi
Katshungu
Nundu
Kama
Lub-Mpaça
Songa, Shaba

Summaries of the available information that, in all cases is incomplete, follow.

Sona-Pangu

Location. Sona-Pangu is a village in Bas-Zaïre about 21 km off the highway between Kinshasa and Matadi. The total distance from Sona-Pangu is about 300 km from Kinshasa and 98 km from Matadi.

Description. A micro-hydropower plant of 20 kW (built in 1935) is on the Lunionzo River, a tributary of the Zaïre River. Equipment failure has rendered this plant inoperative since 1974. It is believed that this plant was built according to plans for another project called Banza-Manteke. A report on Banza-Manteke project dated 1929-30 is available from the mission at Sona-Pangu. The turbine was built by Allis-Chalmers, and the electrical equipment was from Westinghouse and General Electric. When operating, this plant served the community and a 120-bed hospital at Sona-Pangu through a distribution system of overhead power lines of 2300 volts and step-down transformers at load centers. About 1,000 people are believed to have been served by the system.

The Sona-Pangu site was visited by Robert S. Thornbloom, engineer, CEUM Karawa on December 17, 1980 (reference Thornbloom report), and by the NRECA team on March 15, 1981.

Findings of these trips suggest it would be reasonable to replace the building housing the plant, install new equipment (turbine, generator,
Location of 13 small hydro sites in Zaire

Zaire

Ngombe-Matadi
Nkamba

Sundi-Lutete/
Mamgembo

Sona-Pangu

Sona-Bata

Songa

Koda/Retshi

Tshabi

Rwanguba

Katshungu
Kama

Nundu

Lubi-Mpata

Appendix C
and necessary electrical equipment), and reconstruct the distribution system, rather than to try to repair the existing plant. An inspection of the rubble masonry dam and the intake canal is necessary to assess their condition and possible use for the new installation. A power market study would be necessary to determine the size of the new plant (capacity and energy, kW and kWh). Other possibilities of providing electricity to Sona-Pangu to be explored include--

(a) Connecting Sona Pangu to SNEL distribution system if that system is to include in a program of rural electrification making use of electricity from Inga Hydropower plant.

(b) Connecting Sona-Pangu to the diesel plant (200-300 kW) in the plantation if feasible. If the diesel plant on the plantation is used, it must serve the schools and the hospital for their very urgent need until the construction of the new hydroelectric plant at Sona-Pangu, which would provide the plantation and the neighboring area with electricity.

(c) Installing a small diesel generator at Sona-Pangu to serve the hospital and schools. This diesel generator could be later used as a backup system for the hydro plant.

Since the dam was observed during a high-water period, the condition of overflow sections could not be determined. The dam appeared to be functional, and the abutment walls are in good condition. The diversion canal headgates will need replacement. The canal itself needs cleaning, weeding, and rehabilitation. A section of the canal now being used as a wasteway to bypass the power plant will need repair; a constructed wasteway at this location would be desirable to bypass flood flows and to assist in maintaining the canal and power plant.

The length of the transmission line was not measured but it is probably on the order of 1.5 km.

The basic system functioned successfully for many years; NRECA therefore believes that replacement/repair of the system would be found to be a sound undertaking. It would be useful to undertake a study of the future power needs prior to beginning construction, since, if more power is needed, this could be accomplished by raising the dam, increasing canal capacity, and installing a larger capacity hydroelectric unit.

Needed for the investigations and planning of the new system are the following:

A topographic survey of dam, canal, and power plant site
A profile along transmission line

31 Appendix C
Low-and high-flow determinations and installation of single staff gauge
An estimation of future power needs and plans for procurement, installation, and maintenance
An assessment of above described questions by qualified engineer.

It is estimated that technical assistance for feasibility and pre-construction planning will require about 1 month's time of a civil engineer, 2 weeks' time of an electromechanical engineer, and 3 weeks time of a five-member survey crew. Engineering work would involve two or three site visits before and after survey work. Estimated costs of this pre-construction planning will be about $21,000.

Sundi-Lutete/Mangembo

Location. The proposed site is at the falls on the Ngudi River about 220 km from Sundi-Lutete village and 30 km from Mangembo village. The nearest major town is Mbanza-Ngungu, 156 km away by unpaved road. Sundi-Lutete and Mangembo are in Bas-Zaïre about 350 km from Kinshasa, and 70 km from the border between Zaïre and the Congo.

Description. The height of the falls was estimated by Dr. Thornbloom to be 15 to 18 m, and the flow was measured at 24 cubic meter/second (rainy weather observation) during his visit on December 17, 1980. The NRECA team visited the falls on March 16, 1981. Some preliminary estimates were made by Thornbloom (reference Thornbloom report). He estimated potential to be on the order of 3,000 kW—adequate to supply Sundi-Lutete and Mangembo. Powerlines to these two load centers would be about 30 km. The hydropower plant, which would replace diesel generators now in use, could also provide electricity to several other nearby villages with a total population somewhere between 60,000 and 100,000. A 180-bed hospital and schools also would be served.

The potential of this falls exceeds 1000 kW—considered as the limit of micro-hydropower projects. It is probably beyond the scale of projects that should be included in the immediate impact element of a USAID project, but it should be studied within the framework of medium-term USAID assistance. The required feasibility study would involve a team of at least one hydrologist/civil engineer, one geologist, one mechanical project economist, and a topographic survey crew. Some foundation investigations should be performed. The technical assistance would be far more costly than that for any of the projects visited by this team. Preconstruction investigations and planning would probably cost on the order of $300,000, and would require about 6 months to complete. A staff gauge should be installed and calibrated with particular attention to low flows.

Rwanguba

Location. Rwanguba is a village about 90 km from Goma, Kivu.
**Description.** Dr. Thornbloom visited Rwanguba on November 13, 1980. The NRECA team visited the site on March 19, 1981. The description is based on these two visits.

Since 1957, Rwanguba has been served by a single source of electricity generated by a hydroelectric plant built by a group of missionaries. The mission purchased the plant's turbine-generator from an American utility company that was modernizing. The Leffel vertical-shaft, propeller-type, turbine-generator was built in 1929 and purchased by the mission for $1.00. This unit has a capacity of 125.8 kW. During the past few years several breakdowns occurred. The worst of these happened in 1978, and left the village and hospital without electricity for 6 months. Maintenance and rebuilding of various components were expedited by the local staff.

**Power plant.** The unit is no longer reliable. Its automatic governing system can no longer keep governor lag or droop within acceptable tolerances, thus necessitating manual control. The gates are worn beyond tolerance, and the vertical shaft above the main bearing is visibly out of round. Given the quality of the materials used and their age, the quality of installation in the transformer, some windings and leads is probably very delicate.

**Forebay.** The major portion of concrete work is functional although work is needed on the gates and control structure. The degree of silting is not known. Abrasive, suspended lava rock in the water is a concern as the rock is very sharp, hard, and rather porous. Care should be taken either to remove it well before entrance to the turbine or to specify resistant materials in construction of the propeller and water passages.

**Distribution systems.** The voltage of the overhead powerlines between the power station and the transformers at load centers within 3 km is 2300 volts; thereafter, it is stepped down to 220 volts. This is very functional, with proper lightning protection.

The power station also houses a diesel generator of unknown horsepower. This unit is not in operating condition now, as its injection system is being repaired at a machine shop some kilometers away.

**Power needs.** A new unit should be installed as soon as possible to ensure continuity of power and service to the hospital and the community. The urgency of installing a reliable power supply is emphasized by the fact that certain hospital life-support systems (such as incubators for premature infants) as well as the X-ray, surgical room, and pharmacy operations are totally dependent on a power supply. The team was informed that two infants now in incubators would probably not survive if another power failure occurred while the standby diesel unit is inoperative.
Water sanitation needs. Of great importance and urgency also is an improvement in the present, wholly inadequate, water supply for the hospital and the waste disposal system for the hospital and school complex. The water is pumped by a hydraulic ram located a few meters from the power plant. But, in part because of the excessive head losses caused by an improperly laid discharge line, the ram does not pump sufficient water to meet hospital needs. For example, the eighty-bed hospital has no inside toilets for the patients. The new power system should provide enough power to pump an adequate water supply to a location from which gravity flow will be possible. Sanitary drainage would not be a problem, since the complex is located on a hilltop.

Preconstruction investigations and planning. A study should be made to determine the power and water needs of the Rwanguba complex over the next 30 to 50 years. The NRECA team believes that power can be generated both by the rehabilitation of the existing site, and the development of a downstream site with a 600-800 kW potential. The team believes that the urgency of the situation calls for the immediate rehabilitation of existing site, while the feasibility study (including the environmental and social assessment) of the downstream site is being conducted. In the long run, both sites could provide power to the area.

The technical services required for investigation and planning of the rehabilitation/improvement of the existing site (including increased water supply) are estimated to be--

Civil engineering--One month's work (part to precede, and part to follow the survey) is required to direct enlargement of the station, lengthening of the forebay, replacement of the wooden gates, selection of new turbine, supervision of site surveys, design of water supply and sanitation systems, cost estimation, and to supervise survey work.

The electromechanical engineer is needed to design and to draw up specifications for the generator and other mechanical equipment, including the transmission/distribution lines. His services are required for one week following the completion of the survey and should overlap in time with those of the civil engineer.

Survey work--A site survey should be conducted to determine the best method for enlarging the existing building, lengthening the forebay, installing staff gauges for flow measurement, and for determining the length of transmission/distribution lines. This will require 3 weeks work.

Economist--A feasibility analysis of the downstream site and an economic/financial analysis of rehabilitation of present site should be conducted. The existing site requires only minimal analysis.

It is believed that the church mission can accomplish some of the preconstruction and construction work with local resources. But
some USAID assistance, chiefly in the form of financial assistance, will be needed. Preconstruction investigations and planning for the existing site could probably be accomplished with about $30,000 in USAID assistance. NRECA recommends the immediate funding of the impact element of the project using, if available, USAID design funds.

Koda Hydroelectric Project, Retshi, Haut-Zaïre

Location. Retshi is about 160 km from Bunia. The nearest town is Mahagi, about 40 km distant. Mahagi is only 9 km from the border between Zaïre and Uganda.

Description. A hydroelectric plant is proposed for the Koda River Falls to provide electricity to Retshi (100 kVA). Kwandruma, a small town some 10 km distant from Retshi will receive 25 kVA via a high-tension line from the site.

The proposed plan is described in a report prepared in October 1980 by Dr. Paul Brown. Besides the communities, the Koda Hydroelectric Project will serve the hospital at Retshi, primary and secondary schools, Retshi Academy, Retshi Mission Station, professional services (optical, dental, pharmacy), printing press and literature production (CECA), and local crafts shops. Kwandruma has 2,332 residents and 22 merchants. Retshi Mission has 1,386 residents and 40 foreign residents.

The site was visited by Dr. Thornbloom in October 1980. The assessment of this site is based on his visit and the report by Dr. Brown.

Status of Project. Planning and stockpiling of materials appears well advanced. Cost estimates in the Brown report are reasonably detailed and indicate a cost of about $1,700 per kW of installed capacity. This is a rather high cost, but in view of the cost and uncertainty of diesel power, the NRECA team believes the project to be economically feasible. J. Propst, a civil engineer, will provide the needed engineering services. The NRECA recommends that USAID consider a project grant of $170,000 subject to the following considerations-

1. A finding that USAID funding either will not be used for the purchase of non-U.S. (or ineligible supplies) equipment, or that a waiver of source can be justified. In the latter case, a request for German (FRG) assistance should be made first

2. Certification of the qualifications of the consulting engineer

3. Acceptance of the design of the power station building to accommodate eventual installation of additional units

4. Designation of a project manager acceptable to USAID and acceptance of normal USAID reporting requirements

35 Appendix C
5. A finding by a qualified engineer that development as proposed would be compatible with future energy requirements of the load centers and with future, more comprehensive development of the Koda River Falls.

6. Approval of site development by appropriate government authority.

7. A brief, but adequate and favorable analysis of economic, financial, environmental, and social feasibility factors.

8. Preparation of a plan for operation and maintenance, and for user charges to help cover costs.

NRECA also proposes that further, more comprehensive studies of power development (in excess of 120 kW) and consideration for water supply and pumping requirements be carried out. USAID should provide assistance under its medium/long-term framework project if necessary. It is further proposed that the powerhouse be modified to provide for the future installation of two more units of 120 kW and for the necessary intakes.

Ngombe-Matadi

Location. Ngombe-Matadi is a village in Bas-Zaïre about 50 km from Mbanza-Ngungu and 230 km from Kinshasa. The road between Mbanza-Ngungu and Ngombe-Matadi is unpaved.

Description. In his visit to the site on December 18, 1980, Dr. Thornbloom determined that a 140 kW hydroelectric project was started by a Belgian mission sometime before 1980. The work by the mission included the pouring of some concrete, and the transportation of the penstock, turbine, and generator to the site. Site investigations by the NRECA team are needed to measure flow and to establish design criteria for the project. Additional needed materials and equipment should be identified, and cost estimates should be made. A redesign of the power market is also necessary.

Since the Inga Shaba power line passes within 10 km of Ngombe-Matadi, electrical power might be more effectively obtained by use of the SNEL distribution grid than through the installation of a hydroelectric plant. This alternative should be considered.

Ngombe-Matadi is about 20 km from Nkamba, another village in need of electricity that has applied for USAID assistance in building a microhydropower plant. The possibility of combining Ngombe-Matadi and Nkamba into one regional hydroelectric power development should be considered.

It is proposed that this subproject be considered by USAID for inclusion in the USAID Small Hydropower Project. It could be studied by the technical assistance group and, if deemed necessary, assisted either through immediate impact assistance or longer term assistance. It is further suggested that the Belgian Embassy be
contacted to determine why the project was abandoned, and current Belgian interest in it.

**Nkamba**

**Location.** Nkamba is a village in Bas-Zaire about 70 km from Mbanza-Ngungu and 250 km from Kinshasa. The road between Mbanza-Ngungu and Nkamba is unpaved.

**Description.** The assessment is made based on visits by Ron Mininger and Dr. Thornbloom in October and December of 1980. There are two possible sites for hydroelectric installations present. One is at Motake Falls about 12 km from the village. The potential at this site is far more than is needed for Nkamba community. The head at the other site was estimated by Thornbloom to be about 30 m and the flow 0.066 cubic meters/second. The power potential could be on the order of 5-15 kW.

There has been some previous work done on the stream at the falls. Some of that work might be incorporated into a new installation; however, the foundation conditions should be checked to ensure its adequacy.

According to Engineer Thornbloom, an additional 5-10 m of head could be obtained by a considerably longer penstock. The flow is very small and observed during rainy season only. Accurate flow measures are needed for the dry season (September-October) before it can be determined if the power potential is sufficient to warrant development.

Since the Inga-Shaba powerline passes within 10 km from Nkamba, the possibility of securing electricity through the distribution grid suggested for study by SNEL should be considered.

As noted above, Nkamba is about 20 km from Ngombe-Matadi, and the possibility of an integrated system between the two villages should be considered.

It is proposed that this subproject be considered by USAID for inclusion in the USAID Small Hydropower Project, subject to further study by the technical assistance group under that project.

**Sona-Bata**

**Location.** Sona-Bata is on the Matadi-Kinshasa Highway, about 80 km from Kinshasa. The presence of three religious communities (Protestant, Catholic, and Kimbanguist) make it unique.

**Description.** The assessment is made based on the submittal, dated May 15, 1980, by the Communauté Baptiste du Zaïre Quest (CBZQ), Institut Sona-Bata. The request is to provide between 30 and 40 kW of hydroelectric power to the school "Institut Sona-Bata" and the hospital operated by CBZQ.
During the school year 1979-80, the school comprised 12 classes (428 students) in primary education, 8 classes (305 students) in secondary education and 9 classes (416 students) in humanities. At present, the sole source of electrical power is a very undependable diesel generator that runs only 2 hours a day.

The hospital has three doctors, expatriate and Zairian, and supervises 13 dispensaries and maternity centers in the region. It also offers programs in public health and nutrition. Because of its location, the hospital also treats patients from road accidents.

The lack of electricity presents a handicap in providing services to the community and in running its equipment. Some equipment runs on diesel fuel, but the operation costs are very high and there is often a lack of fuel.

The Inga-Shaba powerline runs within 5 km of Sona-Bata. The possibility of connecting to the distribution grid now in planning stage by SNEL should be checked before any further actions.

**Tshabi**

**Location.** Tshabi is located 117 km south of Bunia, Haut-Zaïre. The road between the two towns is unpaved.

**Description.** This assessment is based on a report made by Dr. Thornbloom in November of 1980. Also available is a report made by Pearl Winterbun of USAID. Miss Winterbun's report is nine pages in length and includes a map.

Dr. Thornbloom identified two possible sites:

**Motake Falls (within 5 km of Tshabi)**

- **Head:** 17 m plus
- **Run:** 48 m length of penstock
- **Flow:** 0.302 cubic meters/second measured on January 11, 1980, fairly constant year-round
- **Power:** 50 kW approx.

**Ababiba Falls (within about 3 km of Tshabi)**

- **Head:** 30 m plus much more
- **Run:** 40-60 m
- **Flow:** 0.12 cubic meters/second
- **Power:** 20-40 kW

**Remarks:** Very low flow in dry season, steep banks. It should be considered in depth if project moves toward implementation.
A hydroelectric power plant could be built at one of the falls to supply Tshabi Health Center with a 24 hour per day supply of power. An electric pump should be installed with the project to provide adequate water supply. NRECA recommends both possibilities be studied further as potential USAID projects.

**Katshungu**

**Location.** Katshungu is about 185 km west of Bukavu, Kivu, by unpaved road.

**Description.** A site with a hydroelectric potential of 7 to 12 kW was identified by Dr. Thornbloom. There is a hospital in this remote village, but no doctor at present. This site should be evaluated according to USAID guidelines.

**Nundu**

**Location.** Nundu is on Lake Tanganyika, about 170 km of Bukavu, the capital of Kivu. The nearest town to Nundu is Uvira (45 km). The road between Bukavu and Uvira is asphalt.

**Description.** The assessment is made based on Bard Jackson's report of the meeting on December 30, 1980, in Seattle, Washington, with the First Free Methodist Church and the report of site visit in October 1980 by Dr. Thornbloom.

A small hydroelectric project was planned by the First Free Methodist Church, with assistance of a group of engineers from Seattle, to provide electricity to the hospital in Nundu. The power plant, which will have a capacity of 100 kW, is in development stage with some funds from the PVO on hand. The turbine-generator equipment has been ordered and the electrical distribution equipment collected. These materials were to be shipped to Zaire in March 1981 provided that funds were raised in time. The group is now unable to fund the entire project and has asked USAID's assistance. Bard Jackson reviewed the civil designs and offered some minor comments.

He felt that the design is workable, the engineers competent, and the project worthwhile.

The installation to be accomplished includes—

- construction of a concrete dam and forebays
- excavation of a 6500-foot-long water canal to a point, 225 feet
- construction of powerhouse
- excavation of the tailrace
- supervision of installation of electrical system (by engineer Layton Pickett).
From the available information, which is quite fragmentary, it appears that supplemental funding of less than $100,000 is needed to complete this project. NRECA recommends that this subproject be included in the immediate impact assistance part of USAID's project, subject to a "screening" review. The screening review should be performed by the technical assistance group and should consider design elements only. The extensive participation by the PVO in this project is a good indication that the necessary initiative for a successful project exists at Mundu.

**Kama**

**Location.** Kama is west of Bukavu, Kivu Region.

**Description.** The local government requested assistance in connecting their community with hydropower at the Kitangi mines (51 km distant).

NRECA recommends that this assistance request be considered as part of the immediate impact element of the USAID project.

**Lubi-Mpata, Hydroelectric Project, Kananga.**

**Location.** Lubi-Mpata is about 30 to 40 km southeast of Kananga. Access to the site is by an unpaved road.

**Description.** The assessment of this project is based on the field report by J. A. Carlen and Lee McMichen. A detailed description of field conditions is given in that report. The Lubi-Mpata Hydroelectric Project was planned and designed more than 6 years ago, and construction started 2 years ago. For the most part it is funded by IMCK Presbyterian Mission. The resident engineer is Mr. Sharp. He is assisted by John Metzel, a mission volunteer who speaks the local language (Chiluba). Mr. Sharp estimates that 2 more years will be required to complete the project.

The hydroelectric facility is being constructed mainly to serve the hospital. The hospital has space for 120 patients and provides full medical services for residents of Kananga and the northern parts of Shaba provinces. It has six full-time doctors and is fully electrified. A 200-kW diesel generator is run during the day to supply power for lighting, operating rooms, X-ray and support equipment, and water pumps. The cost of diesel fuel is now above 250,000 zaires per year. This represents a significant part of the hospital's yearly budget.

The generating unit for the hydroelectric plant is being built by the Ossburger Company in Germany, and includes turbine, governor, generator, exciter, and voltage regulating equipment. Delivery of the equipment is expected in 2 to 3 months. The turbine is of the horizontal-shaft impulse type. The generator is rated 180 kW at 400 volts, 50 hertz. The power will be transformed to 7.2 kW and carried to the hospital via an underground cable.
The following observations were made by Messrs. Carlen and McMichen.

At the dam site, the six spillway piers have been excavated to bedrock and anchored with rebar grouted in place. The area being excavated by hand labor will allow diversion of the river for future construction of the concrete dam across the main channel of the Lubi-Mpata River. The riverbed has a solid granite bottom, which appeared to be suitable for anchoring concrete piers and dam walls. The existing feeder channel embankments appear to be constructed of dump fill removed during excavation of the canal. The soil appears to be a light orange-brown decomposed laterite, having a poorly graded sand-silt mixture with very little plasticity. Such soils are generally classified as semipervious, with good shear strength when compacted properly. However, laboratory and/or in-site soil testing should be performed as necessary to ensure the soundness of the embankment.

The Caslen/McMichen report also recommended lining the diversion canal to prevent excessive erosion. Hydrologic investigations of flood potential at the site were also recommended and should be carried out to ensure safety of the installation.

There appears to be a need for additional investigations and planning for this site, and NRECA recommends that these be completed as soon as possible. If necessary, this can be done with technical assistance proposed for this project.

Songa

Location. Songa is 95 km from Kamina, Shaba region. There are a number of small villages within 40 km of Songa including Mulambwe, Kafungu, Mato, Kalomoni, Kipukwe, Kyumbo, Samba, and Lubinda.

Description. At present, the mission's electricity comes from a diesel generator which supplies 50 kW each evening for 2½ hours; the generator consumes at least 66 drums of diesel fuel a year.

A potential site for hydroelectric development was identified by Dr. William C. Richi, an American missionary. Though a practicing physician, Dr. Richi built, installed, and maintained two hydroelectric plants during his missionary years in the Philippines. He provided the following site information:

Location: A rapids in a stream about 6 km from Songa Mission.

Head: Could be bypassed to provide 53 feet.

Power: 250 horsepower for a 100 kW generator. 15,000 volts, three phase, 50 hertz.
Distribution: Three-phase transformer to supply the mission at 230 volts, three phase and single phase.

Dr. Richi sees his requirements for this project to include:

A powerhouse with generator, switchboard, stepup voltage transformer, hydraulic turbine, and waterways at streamside below the rapids.

A steel penstock 410 feet long and 2.5 feet in diameter.

Forebay with strainers to remove foreign material from the water, off gates to stop the water flow when necessary, and surge reserve capacity to store water supplied by the canal.

A canal 897 feet long, 6 feet wide, and 4 feet deep, discharge rate of Richi, 3 feet per second. It was estimated by Dr. Richi that 54 cubic feet/second would be required to produce the specified amount of power.

A powerline 6,048 meters long.

Sixty power poles with fittings and insulators for three positive wires. The fourth wire, being neutral, would be placed on top to serve as a lightning arrester.

This hydroelectric scheme should be evaluated under the USAID project for possible immediate impact assistance. There appears to be strong local initiative and capability within this PVO.
Appendix D

Contacts made in Kinshasa

SNEL

Munga Mibindo, P.D.G.
Mutanda Ngoy Myana, Directeur, Equipment Matanda Fundani
Male Cifarha, Jeologue Service Geotechnique (travelling with
    team to Bas-Zaire)
American Consultants--SNEL
Dave Mort, Water and Power Resource Service
    J. A. Carlen, Water and Power Resource Service

C.I.S.

James L. Ferry, Directeur General--Resident
Jim Miller, Administrative Officer
Jack Longland
Jack Logan

U.S. Embassy

Ambassador Oakley
Joseph Williams, Economist
Timothy P. Hamser, Economist

UNDP

M. Labbens, Representant Resident

PLAN

Mikobi, Director of Counterpart Fund
Bombito, CF

Department of Energy

Seka Buhoro, Secretary of State
Simanga, Conseillor Principal

SPE

Prof. Mabu
Zodi Swekolo, Mechanical Engineer
Vika di Panzu, Electrical Engineer
Mboko Makay, Electrical Engineer
Appendix E

References

1. A methodology for country assessments of mini-hydropower potential. Small Decentralized Hydropower (SDH) Program, International Programs Division, NRECA, Washington, D.C.

2. A methodology for prefeasibility studies of candidate mini-hydro sites. Small Decentralized Hydropower (SDH) Program, International Programs Division, NRECA, Washington, D.C.

3. Small hydroelectric power plants, an information exchange on problems, methodologies, and development, August 19-21, 1980, Quito, Ecuador, NRECA publication.

4. Small hydro, some practical planning and design considerations by John Stuart Gladwell, Director, Idaho Water Resources Research Institute Professor, Department of Civil Engineering, University of Idaho, Moscow, Idaho 83843, April 1980.

5. Low cost development of small water power sites by Hans W. Hamm, VITA, 3706 Rhode Island Avenue, Mt. Rainier, Maryland 20822, 1967.


8. Various trip reports by Robert S. Thornbloom, Engineer, CEUM Karawa.


12 **The need for a hydroelectric plant for Songa** by Dr. William C. Richli, M.D., Project Director, Songa Mission, D/S Kamina, Haut Lamani, Zaire, April 1980.


14 Colloque sur l'Energie, Republique du Zaire, Kinshasa, Feb. 25-26, 1980, communication de la SNEL.


17 Hydroelectric power and improved water supply for Rwanguba Medical Center and Rwanguba Community, Zone of Rutshuru, Province of Kivu, Republic of Zaire by A. Randolph Bulger, M.D., Physician and Director, Rwanguba Medical Center.


20 **Banzingi-Tchabi Hydroelectric Project** by Pearl Winterburn, November 1, 1981.


22 **Topographic maps**: 1:50,000 contour maps are available for some areas by special permission from the government.

23 **Climatologic and Hydrologic Records**: Not generally available since the revolution.
Appendix F

Team composition

Members of the team whose work provided the basis of this report are--

J. Howe--Team Leader, Engineer. NRECA Consultant/Shaladia Associates.

S. Omkar--Engineer and Economist. NRECA Consultant/Acres-American/Shaladia Associates.

The following worked with the team during the periods shown and provided helpful suggestions to the team during the periods indicated:

R. Thornbloom--Engineer, Karawa Project. (March 9-14, 1981)

Sokolua Lubanzadio--Assistant Program Officer, USAID. (March 16-22, 1981)